

SKYSCRAPER SHAKER

Teacher's Guide

DEVELOPED BY:

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Background and instructions by Deborah Harden and Kelly Bringino, Department of Geology, San Jose State University, San Jose, CA.

PURPOSE:

The purpose of this activity is to build a simple device to demonstrate the effect of vibration frequency on seismic shaking and to explore the relationship between building height and seismic shaking.

SUGGESTED STUDENT GROUPING:

One model can be used to demonstrate principles to the entire class, or students capable of simple carpentry can build their own model.

FRAMEWORK INTEGRATION:

Integrating with other disciplines: Physics (properties and behavior of waves).

RELATED ACTIVITIES:

Earthquake Wave dance; The Domino Effect; Earthquake Survey.

BACKGROUND INFORMATION

The severity of shaking during an earthquake depends on several factors. Aspects of ground shaking that are directly related to the earthquake itself include the magnitude of the earthquake, the distance between the observer - or should we say participant - and the epicenter, and the type of motion along the fault. Other factors unrelated to the earthquake include type of soil or rock beneath the observer, the

water content of the soil, and the type of structure which is shaking. Because earthquake damage is directly related to the amount and duration of shaking, it is important to consider these factors when designing structures in a seismically active area.

All buildings, bridges, and other structures have a natural **frequency** of vibration, which is strongly dependent on the height and shape of the structure. Earthquakes generate a variety of seismic waves which travel outward from the source to the Earth's surface. The rocks and soils near the ground surface in turn vibrate with a characteristic frequency. If that ground motion matches the natural frequency of a building, the shaking of that building is amplified. As a general rule of thumb, the natural **period** of buildings is about 1/10 second per story (for example, a 10-story structure would vibrate with a period of about 1 second). As a result, shorter buildings respond to high-frequency, short-wavelength vibrations whereas taller structures sway with long natural periods in response to low-frequency, long-wavelength earthquake vibrations (Fig. 1).

Body waves (P and S waves) range widely in frequency, but the most pronounced frequencies are relatively high (.5 to 20 Hertz or cycles per second) (Keller, 1988). In contrast, surface waves have frequencies of less than 1 Hertz. Because low buildings have higher natural frequencies than taller structures, body waves with relatively high frequencies, cause low buildings to vibrate whereas surface waves with low frequencies cause tall buildings to vibrate (Keller, 1988).

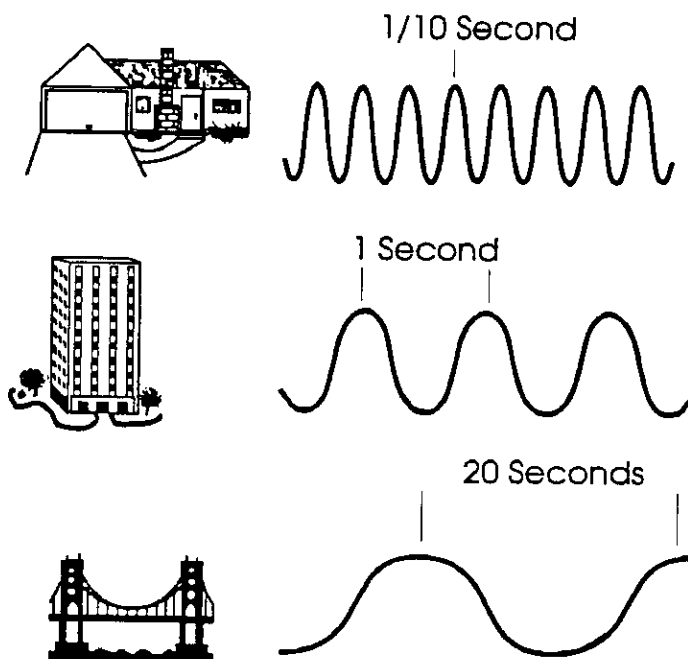


Figure 1. High-frequency, short-wavelength vibrations affect relatively short structures such as houses. Low-frequency, long wavelength vibrations are amplified in tall structures and long suspension bridges (modified from the *San Jose Mercury News*, January 24, 1994).

MATERIALS:

- 1 piece of wood (21" X 4.25" x 0.75" works well)
- 2 pieces of welding wire
 - one 24" long
 - one 12" long
- 2 small wooden blocks (1" cubes)
- 1 nail
- hammer

SOURCE OF MATERIALS :

Wood and wire can be found at a home supply or hardware store. Wooden cubes are available in many hobby or craft stores.

PROCEDURE:**Making the model**

- 1) Using a nail with a slightly larger (or equal) diameter than the welding wire make a 1/4" deep hole on each end of the large piece of wood as shown in Figure 2 a.
- 2) Use the nail to make a 1/4" hole in the center of each of the wooden blocks (Fig. 2b.)
- 3) Fit the welding wire into the holes as shown (Fig. 2c).

Demonstrating the effect of frequency vibration on building shaking

- 1) Generate short, high frequency waves by sharply jolting the model. Under these conditions, the taller "building" remains relatively stationary, but the shorter "building" shakes strongly.
- 2) If the device is swayed more steadily to simulate long, low-frequency waves, the opposite effect is produced.

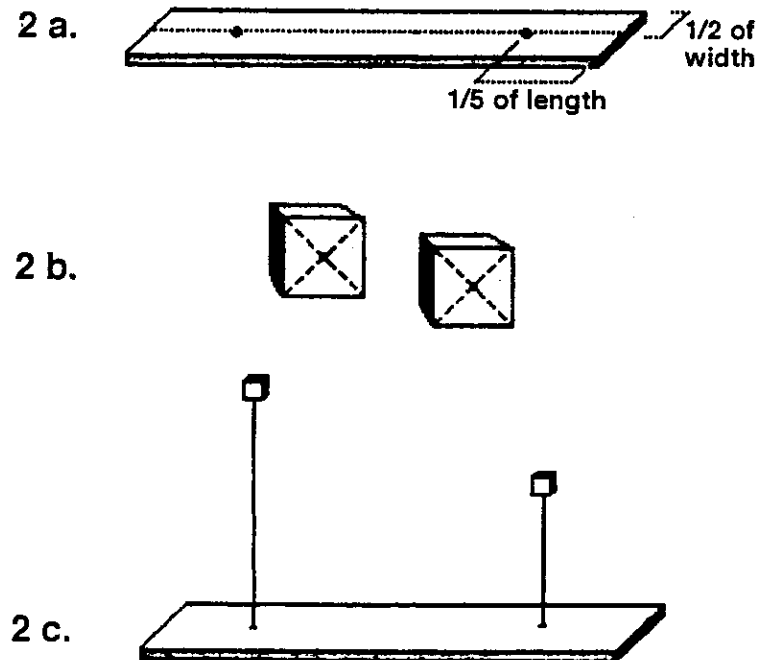


Figure 2.

REFERENCES CITED:

Keller, 1988, Environmental Geology, 5th ed.: Merrill Publishing Company, New York.

ADDITIONAL REFERENCES AND RESOURCES :

Bolt, B.A., 1993, Earthquakes: W.H. Freeman and Company, 331 p.

Publications from the Federal Emergency Management Agency (FEMA):

- FEMA Earthquake Hazards Reduction Series Publications.
- FEMA, Non-Technical Explanation of the NEHRP Recommended Provisions, FEMA-99.

For information about these and other FEMA publications write to: Federal Emergency Management Agency, P. O. Box 70274, Washington, DC 20004.

See also the **Background Information** section of the *Earthquake Wave Dance* activity for more information about seismic waves.